DEVELOPMENTAL PARAMETERS OF THE EAR ASYMMETRY PHENOMENON: THE EFFECTS OF SEX, RACE, AND SOCIOECONOMIC CLASS

By

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DEDICATION

To my wife, Pat, whose being makes mine worthwhile.

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Abstract of Dissertation Presented to the
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This study investigated parameters of the ear asymmetry phenomenon. This study attempted to discover what effects the variables of age, sex, race, and socioeconomic class have on ear asymmetry.

The ages of the children used as subjects were five, seven, nine, and eleven. The initial age of onset of ear asymmetry was found to be five years of age with a developmental trend of increasing asymmetry as a function of increasing age. This trend, however, did not reach statistical significance. Significant between ear effects were found at all ages. Males were found to develop essentially the same as females and white children develop the same as black children on dichotic listening tasks, which were utilized as the criteria measures of ear asymmetry. There were significant social class differences found, the middle class S's showing a significantly greater degree of asymmetry than their lower class counterparts. All ages in both social classes, however, showed a significant right-left difference in favor of the right ear. Possible explanations for discrepant findings between the present study and other research are discussed.

PROBLEM

Functional asymmetry of the human brain in relation to speech has recently been studied by the utilization of dichotic listening tasks. Since Broadbent's (1954) initial use of the dichotic listening technique in studying memory, it has also been widely used as a measure of the ear asymmetry phenomenon. A dichotic listening paradigm involves auditory stimuli being presented to subjects through stereo headphones. Stimuli are presented as disparate pairs (spoken words, digits, nonsense syllables, and musical rhythms) which arrive simultaneously at each ear. These pairs are presented in clusters of varying lengths and at various rates. At the end of each cluster or trial the subject is asked to report verbally the stimuli which he perceived.

The ear asymmetry phenomenon relates to the fact that when verbal stimuli are presented, it has been consistently found that adult subjects recall stimuli more accurately from the right ear than from the left ear (Dirks, 1964; Bryden, 1967). Conversely, when nonverbal stimuli are utilized, adult subjects have superior recognition from the left ear as opposed to the right (Curry, 1967). Similar evidence has been found in dichotic listening studies which utilized children as subjects (Kimura, 1967; Knox and Kimura, 1970). These "preferences" theoretically reflect a cerebral dominance for the perception and/or integration of auditory stimuli; the left hemisphere being dominant for verbal stimuli such as words and digits, and the right hemisphere being dominant for nonverbal auditory stimuli. Clementino, Wilder, and Mayersdorf (1970), utilizing the Sodium Brevital technique for determining cerebral dominance for speech, found that those patients who were determined to be left hemisphere dominant for speech had superior recall for digits presented to the right ear, and those that were "right brained" for speech had superior recall from the left ear. Kinsbourne (1973) studied several patients who had undergone hemispherectomies and found that in a dichotic listening situation the patients had very little success in reporting the materials presented contralateral to the absent hemisphere.

Physiological evidence from animal studies suggest that the auditory pathways in the brain are stronger contralaterally than they are ipsilaterally (Rosenzweig, 1951). A similar study in man (Bocca et al., 1955) lends support to the animal findings. Recent anatomical evidence from corpus callosum bisection studies (Gazanaga, 1971) shows that in addition to the direct pathways posited by Kimura (1967), the transcallosal auditory pathways play an extremely important role in auditory perception.

There remain, however, many aspects in this area which to date have not been conclusively answered. The present study attempts to discern the relative importance of several variables in relation to the ear asymmetry phenomenon. The dichotic listening technique utilizing verbal digits will be employed as a tool in attempting to discover what effects certain variables have in relation to ear asymmetry. The variables to be studied include Age, Sex, Socioeconomic Class, and Race.

Age

Kimura (1963) has found evidence of an ear asymmetry in children as early as age four. In this study the greatest ear asymmetry effects were found in the youngest subjects. It is felt that the simplicity of the stimulus task employed in this study caused the younger children to appear to have a greater amount of asymmetry than the older children. As the children developed, they were able to approach a "ceiling" of reporting almost all the numbers heard in both ears. As Kimura used difference scores between the ears as her measurement criterion, these differences diminished as a ceiling level performance was approached. Nagafuchi (1970) found an even earlier age of onset of ear asymmetry. He found that his three year old subjects showed a significant difference between their right and left ears. Likewise, he also found that the greatest asymmetries were present in his youngest subjects. Again, however, he employed a very simple task composed of single word stimuli for each trial. Two recent studies (Bakker, Satz, Goebel, and Van der Vlugt, 1973; and Darby and Satz, 1973) have contradictory evidence to earlier work. Using a difficult stimulus task, three and four pairs/trial at a rate of 2 pairs/second, they found that a significant ear asymmetry did not develop until much later, at around nine or ten years of age. They also showed that the amount of asymmetry seemed to increase as the age of the subject increased. "Age... is an extremely important variable, with the quality of performance generally increasing with age for both ears. As for the ear variable, we can conclude that the right ear performs significantly better than the left ear only at later ages (although a trend is set up around ages five or six)" (Bakker et al., 1973). Clinical evidence suggests that complete speech lateralization does not take place until sometime after the age of eight. Zangwill (1960) has thus proposed that cerebral lateralization for speech is gradually established during the development of the child.

It seems certain that as the child develops dramatic changes occur in the hemispheric lateralization of speech. Wide discrepancies in the methodologies used to study this problem have produced conflicting results. A further understanding of ear asymmetry in relation to age of onset and development is hoped to be contributed by the present study.

Sex

There has been conflicting evidence as to whether males and females develop differentially with regard to ear asymmetry. Kimura (1963), when discussing her findings states, "There is thus no evidence from these data that speech becomes represented in the left hemisphere any later in boys than in girls, though the possibility cannot be ruled out." In 1967, however, Kimura reports on a study which tested children of a lower socioeconomic class, and thus were presumed to be at a somewhat earlier stage in the development of cognitive function. The study showed that five year old boys did not show the significant right ear effect that their female counterparts did. She thus concluded, "It appears that if one tests children at an early enough stage of development, a sex difference in the development of cerebral dominance may be detected... The data do suggest that boys may lag behind girls in the development of left hemisphere dominance for speech." Bryden (1970) in a study on children in grades 2, 4, and 6 found that, "there are very major sex differences: the adult pattern emerges in girls earlier than in boys." Nagafuchi (1970) found his females to be superior to males at the age of three but not in the older age groups. Bakker et al. (1973) utilizing multivariate statistical techniques determined that for their data the proportion of variance that was accounted for by sex alone was 0.7%. They conclude that, "This is strong evidence that, for this task, sex is a variable without which we could get along very nicely." Knox and Kimura (1970) attacking the same problems as earlier studies found significant ear and age effects, but no sex effects in the children they tested. Two recent studies utilizing CV nonsense syllables as dichotic stimuli (Berlin et al., 1973; and Bryden, 1973) have also found discrepant results in relation to the Sex variable, Berlin finding sex non significant and Bryden finding it highly significant.

In view of the highly contradictory results in the literature and the evidence of great disparities between males and females in a number of learning and behavioral disorders (Bentzen, 1963), the inclusion of sex as a variable to be studied seems justified.

Socioeconomic Class

It is believed that the environment plays a major role in numerous facits of the developing organism. Early environmental stimulation or deprivation has been shown to have significant biochemical effects on the brains of rodents (Diamond et al, 1972, Rosenzweig and Bennett, 1969). In humans Bloom (1964) has found that there are physiological differences between low and middle class children. This study attempts to discover if there is any relation between social class and ear asymmetry.

As stated previously, Kimura (1967) reports on the testing of children from the lower socioeconomic class and found a lag in the five year old males. More recently, Geffner and Hochberg (1971) investigated this question of social class in relation to ear asymmetry across different ages (4-7). They found that "right ear effects were seen for all age groups from the middle socioeconomic level and for the seven year old subjects from the low socioeconomic levels." They concluded that, "The present findings agree with those reported by Kimura (1967) that although children from low socioeconomic areas demonstrate right ear superiority for verbal stimuli, the degree of such superiority is less than that observed for children from middle socioeconomic areas." It is necessary to point out that the stimuli used by Geffner and Hochberg was similar to that used in earlier studies, i.e., less complex. They also employed a 2 pair/trial digit task which was presented at a slower rate, 2 pairs/1.5 sec. vs. 2 pairs/sec., used in most previous and subsequent studies.

Race

It is felt that the selection of subjects in Geffner and Hochberg's study may have had a significant effect on their findings. They state, "the large majority of children from the low socioeconomic group were of black origin, whereas the children from the middle socioeconomic group were predominately white. What, if any, influence these factors may have contributed to differences in performance cannot be ascertained from the present study. It is more than likely that various factors were operating to influence the performance of these children. The nature of these factors and their consequent influences are not clear" (1971).

It cannot be determined from their study whether the results they found were due to socioeconomic differences or to racial differences. The question of racial differences in ear asymmetry has not yet been studied. This is a question where some exploratory data is long overdue.

The present study proposes to shed further light on relative dimensions of the ear asymmetry phenomenon. Subjects will be tested utilizing the dichotic listening technique. Subjects will be both male and female; five, seven, nine, and eleven years of age. Furthermore, subjects of each of these ages and sexes will be included in groups of middle class white, low class white, and low class black children.

This study is designed to shed light on developmental parameters of cerebral lateralization of speech in children. Ear asymmetry will be utilized to make inferences about cerebral lateralization. Speech lateralization is postulated to be represented in the hemisphere contralateral to the more efficient (i.e., greater total recall) ear. The factors of Age, Sex, Race, and Socioeconomic Class will all be studied in relation to their effects on ear asymmetry.

METHOD

Subjects

Subjects in the present study were children enrolled in the public school system of Alachua County, Florida. Left handed children were excluded from the study. Handedness was determined by verbal report of the subject and preferred hand for several manual tasks. Socioeconomic status was determined from school records concerning the amount of family income, teacher evaluation, and occupation of the parents. The total number of subjects utilized was 120. There were 24 individual cells comprising 5 subjects each. A graphic representation of the subject design is seen in Table 1.

Dichotic Listening Tasks

The dichotic listening task consisted of 30 sets of 3 digit pairs which were presented in such a way that the two digits in each pair were presented simultaneously at the right and left ear. Each trial was presented at the rate of 2 pairs/second. Each trial consisted of three pairs (six digits total). The digits heard on the tape were 1, 2, 3, 4, 5, 8, 9, 10, 12, 13, 14, 15, 18. The tape had been created so that the digits in each pair had the identical onset time and the same loudness. Since there

Table 1

A SCHEMATIC REPRESENTATION OF THE SUBJECT DESIGN

RACE:	WHITE								BLACK			
CLASS:	Middle Class				Low Class				Low Class			
AGE:	5	7	9	11	5	7	9	11	5	7	9	11
SEX:	M-F	M-F	M-F	M-F	M-F	M-F	M-F	M-F	M-F	M-F	M-F	M-F

are auditory differences in spoken digits which cannot be controlled for acoustically, other control methods were necessary. Therefore, the tape was constructed so that the first 15 trials of the tape were identical to the second 15 trials. However, after trial 15 the headphones were reversed on each subject so that the stimuli initially heard in the right ear were then heard in the left and vice versa. In addition to this reversal, the initial placement of the headphones was reversed for every other subject so that half the S's heard channel A in the right ear first and half heard channel B in the right ear first. This constitutes both a within subject and between subject reversal procedure. It can be seen from these methodological controls that each subject heard exactly the same stimuli in each ear. This eliminates the possible bias that some digits which are more readily perceived are presented more often to one ear than to the other ear.

Procedure

Each subject was tested individually by the experimenter. The S's were tested in a quiet room within their own school. The first five trials on the tape were used as practice trials and not counted in the scoring. Subjects were instructed to listen to the stimuli presented on the tapes and verbally report back to the experimenter what they heard. There was no effort made to require that the S's report in any specific order. There was a 10 second intertrial interval in which the verbal reporting took place. The total possible score for each ear was 90. As was stated previously, there was both a within and between subject reversal of the headphones in order to equalize any anomalies in the stimulus production system.

Each subject was administered the Digit Span from the Wechsler Intelligence Scale for Children (Wechsler, 1949). This was utilized as a standard measure of each subjects ability to recall auditorily presented digits.

Statistical Analysis

A form of an applied multivariate regression analysis (Ward and Jennings, 1973) was employed to determine the significance of differences between the variables of Ear, Sex, Age, Race, and Socioeconomic Class. This is a powerful technique which allows the experimenter a great deal of flexibility to test models appropriate to his special problems. It also is very useful in correctly interpreting the data, in that utilization of this technique allows the experimenter not only to determine the significance of differences but also gives him an accurate indication of the total amounts of variance which can be attributed to each variable individually.

RESULTS

The present study attempted to answer several questions concerning the ear asymmetry phenomenon. Several hypotheses in relation to Age, Development, Sex, Race, and Social Class were formulated. It was hoped that the roles these variables play in relation to ear asymmetry could be clarified, and thus a better understanding of the pattern of speech lateralization could be realized.

The data in the present study were analyzed utilizing several techniques. The main analysis performed was an analysis of regression (Ward and Jennings, 1973). Using this technique, the experimenter formulates his hypotheses in terms of linear mathematical models, which are analyzed as regression equations. Associated with each regression equation is the multiple correlation coefficient, which when squared is equal to the percentage of the total variance of the criterion variable that is accounted for by the predictor variables. Any two models can thus be tested for their relative efficiency by comparing their squared multiple correlation coefficients using F tests. This technique was chosen for the main analysis for several reasons. First, it is a multivariate technique which has more power than a series of univariate techniques. Secondly, it allows the experimenter to formulate natural language questions and to translate these into linear models. These linear models are utilized in an analysis of regression. This allows for the forming of specific questions geared to the experiment directly. Finally, through its squared multiple correlation coefficient, it allows the experimenter to determine the potency of his findings by knowing the percentage of the total variance that each of his independent variables accounts for, in relation to other sources of variance.

Ear

An overall measure of ear asymmetry was determined by utilizing the between Ear main effect. It was found that there was a highly significant and potent difference in the recall of data presented to the right and left ears, (F=10.59, df=4/232, p<.01).

Age

The between Age effect was also found to be highly significant, (F=21.23, df=4/232, p<.01). Inspection of Figure 1 illustrates the significant differences between ears at each of the four ages tested, thus showing an onset of ear asymmetry by age five years. Although there was no significant Ear X Age interaction found, a graphic representation of the data reveals a definite trend in the direction of an increasing ear asymmetry with increasing age (Figure 2). The means of the right ear scores for the four ages of five, seven, nine and eleven years were: 40.9, 45.6, 53.4, and 56.4. The mean left ear total scores for the four ages were: 35.0, 40.2, 45.6, and 46.9.

Figure 1

EAR SCORES PLOTTED ACROSS AGE

TOTAL SAMPLE

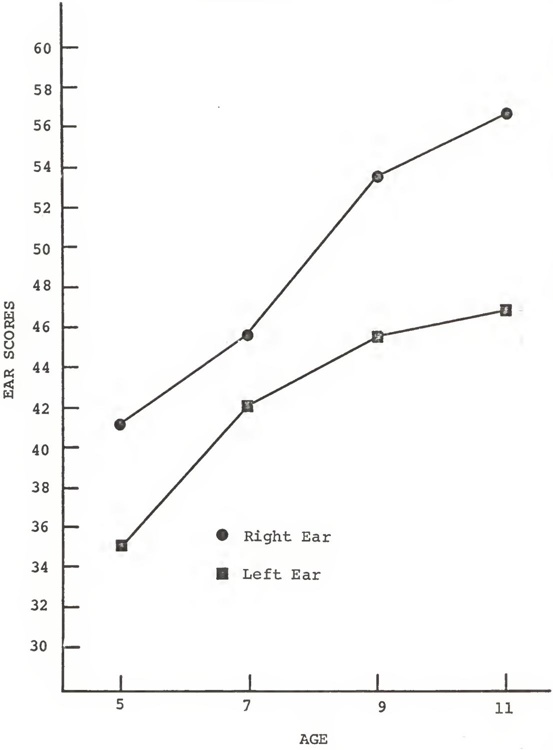
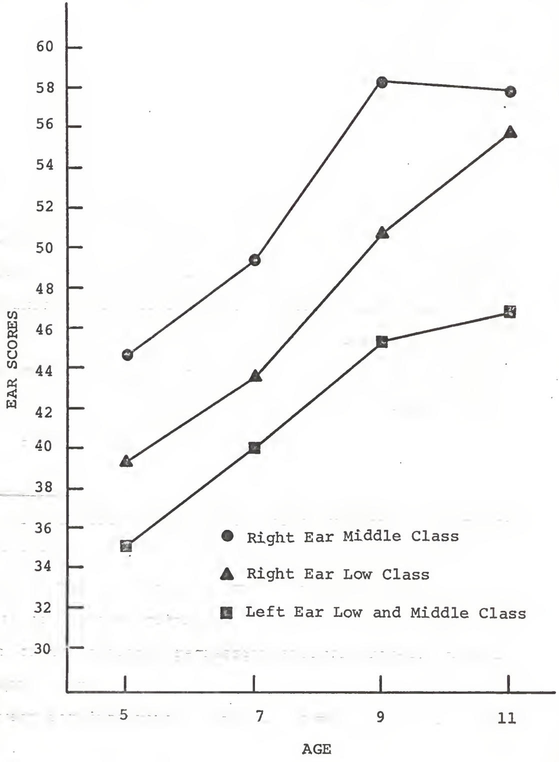


Figure 2

EAR SCORES PLOTTED ACROSS AGE BY SOCIAL CLASS



Race

Two analyses of covariance and an analysis of variance were performed in order to provide initial information as to which variables did not approach significance and could thus be easily and validly pooled in subsequent regression analyses. It was found that there were no between Race main effects or interaction effects in any of these analyses, ($F=.10$, $df=1/127$, $p>.05$).

Sex

The Sex variable was similarly analyzed and it was found that there were no between Sex main or interaction effects, ($F=.46$, $df=1/127$, $p>.05$). In order to determine the exact amount of predictive accuracy that was being given up by pooling Race and Sex, an appropriate regression model was constructed, and it was found that when both these variables were taken out of consideration, there was only a 3.5% loss of accounted for variance.

Social Class

In relation to the social class variable, it was found that there was a significant Social Class main effect, ($F=2.98$, $df=4/232$, $p<.02$). The data pertaining to Social Class can be seen graphically in Figure 2. A further extension of the original regression analysis reveals that in looking at the middle class only, there is a significant between ear difference, ($F=16.26$, $df=1/235$, $p<.01$). Also, the low class taken independently is found to have a significant between ear difference, ($F=21.76$, $df=1/235$, $p<.01$).

These between ear differences are significant for both social classes at all ages. It is further seen that the data for the left ears of the low and middle class are not significantly different from being equal and can thus be combined to form one set of left ear data. It is shown, however, that there are significant differences between the right ears of the low and middle class, $(F=8.02, df=1/235, p<.01)$. In addition, it can be seen from Figure 3 that the right ear scores of the five, seven and nine year olds from the middle class are approximately equal to the right ear scores of the seven, nine and eleven year olds from the low class. This reveals about a two year lag in the attainment of total right ear recall between the social classes.

A separate analysis of regression was performed which included Digit Span scores for each S as a covariate. The results of this analysis reveal a highly significant between ear main effect, $(F=12.93, df=4/231, p<.01)$. There are, however, no other significant main or interaction effects when the covariate is included in the regression analyses.

Table 2 shows a summary of results of several regression analyses including the F score and significance levels of each of the variables tested.

Figure 3

COMPARISON OF RIGHT EAR SCORES
BETWEEN SOCIAL CLASSES OVER AGE

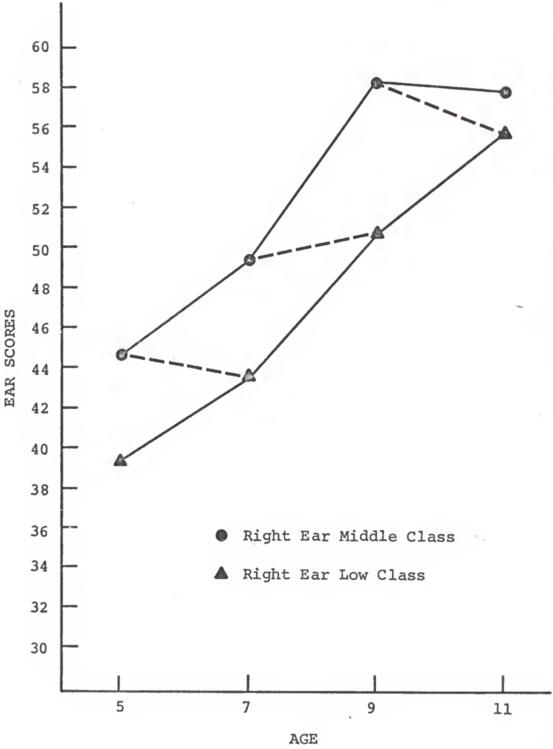


Table 2

SUMMARY OF RESULTS FROM REGRESSION ANALYSES

SOURCE	DEGREES OF FREEDOM	R^2	F	P
EAR	4	.1172	10.59	.0001**
AGE	4	.1237	21.23	.0001**
SEX	6	.0180	1.31	.2501NS
RACE	8	.0285	1.56	.1376NS
SOCIAL CLASS	4	.0337	2.98	.0197**
EAR X AGE	2	.0118	2.14	.1175NS
EAR X CLASS	4	.0165	1.49	.2047NS
EAR X AGE X CLASS	3	.0133	1.59	.1892NS
RT. EAR BET. CLASS	1	.0224	8.02	.0052**
LT. EAR BET. CLASS	1	.0015	0.54	.5326NS

DISCUSSION

Almost every major study utilizing a dichotic listening paradigm has found a strong overall Ear effect. The present study confirms these findings. There can no longer be any doubt that in the dichotic listening situation verbal stimuli presented to the right ear ~~is~~ are reported significantly more than identical stimuli presented to the left ear. If, indeed, this ear asymmetry can be viewed as a representation of concomitant speech lateralization in the brain, it provides strong evidence of left hemisphere dominance for speech. This corresponds to vast amounts of clinical evidence (lenneberg, 1967; Zangwill, 1960).

A determination of developmental parameters of the ear asymmetry phenomenon was of primary importance in the present study. The finding that there was a significant between Ears effect at each age level studied indicates that even in the five year olds ear asymmetry is present. This confirms the previous work of Kimura (1963), Knox and Kimura (1970), Nagafuchi (1970), and Berlin et al., (1973). There is a growing amount of evidence that a true ear asymmetry exists at least by the age of five years. Kimura (1963) and Knox and Kimura (1970) report a significant asymmetry at age four years and Nagafuchi found similar results as early as three years of age. This must raise the question of whether there is an asymmetry at birth. This question must await more sophisticated techniques before it can be answered conclusively. Two recent studies, however, have not shown an ear asymmetry until much later, around age ten years (Bakker, Satz, Goebel, and Van der Vlugt, 1973; Bryden, 1973; and Darby and Satz, 1972). Thus it seems that the age of onset of ear asymmetry is still in doubt but that the bulk of evidence indicates an early right-left difference.

Intrinsically tied in with a determination of the age of onset of ear asymmetry is the uncovering of the developmental pattern which ear asymmetry follows. The early work in this field (Kimura, 1963; and Nagafuchi, 1970), indicates that the greatest amounts of ear asymmetry were found at the youngest ages. This finding is completely opposed to developmental theory and clinical evidence on speech lateralization in the brain (Basser, 1962). These results can be explained by a "ceiling effect." The stimuli used were relatively simple and as older children were tested they began to be able to recall a very high proportion of the stimuli presented to both ears. Thus there was no room for an asymmetry. The present study utilized a relatively difficult stimulus task, three pairs of digits presented at the rate of 2 prs./sec., which prevented the older S's from easily recalling all the stimuli. A return to Figure 1 will show that there is a strong tendency for the asymmetry to increase as a function of increasing age. This tendency, however, does not reach statistical significance. Nevertheless, it does show that ear differences remained strong throughout the age range of the study; moreover, no evidence of a ceiling effect was observed with this more complex stimulus task. These results partially support the more recent findings of Bakker et al., (1973) and Bryden (1973) who found a similar developmental trend even though they found a later age of initial onset.

Bakker, Satz, Goebel and Van der Vlught (1973) have posited an explanation to account for the apparent discrepancies in the literature regarding age of onset and development of ear asymmetry. They state:

> One possible resolution of this controversy could be achieved by circumventing the distinction between the terms "trend" and "statistical significance." Although reckless at first glance, it may be that the problem exists in trying to apply statistical procedures to verify hypotheses on events and processes in the brain which elude objective scrutiny. It may be, for example, that the left cerebral hemisphere is genetically pre-potent for language acquisition and that this predisposition is reflected in some degree of increased hemispheric asymmetry (and decreased bilateral symmetry) by five years of age. This formulation is certainly compatible with clinical reports on the incidence and recovery of aphasic symptoms in brain-injured children (Basser, 1963; Lenneberg, 1967). The problem, however, concerns translating what is meant by degree of hemispheric asymmetry into statistically meaningful terms.
>
> If one postulates a bilateral though unequal hemispheric representation of speech by five years of age, then more than a simple dichotomy in brain polarization is implied. Translated into statistical terms one should expect to find at least a trend, if not significance, in the ear asymmetry at this age. The data, in fact, from all of the published and unpublished studies are consistent when viewed in this light. However, it should be clear that a significant ear effect at age five should not imply complete unilateral hemispheric dominance. This question can only be examined within a developmental context--namely, does the magnitude of the ear

> asymmetry increase as a function of age and at what age, if any does the asymmetry asymptope? This question is felt to represent a more substantive problem than age of onset of the ear asymmetry. If, for example, no further changes in the magnitude of the ear asymmetry occur after onset, then one would have to strongly question the validity of a brain maturation model (i.e., age changes in hemispheric participation of speech) and clinical reports on recovery of speech in brain-injured children (Basser, 1963; Lenneberg, 1967; Zangwill, 1960).

It must be recognized that even if there are statistically significant differences between right and left ear performance, this data cannot be interpreted as evidence of complete cerebral lateralization of speech in the hemisphere contralateral to the ear from which the greater amount of material was reported. It may be that the statistically significant asymmetries found at early ages reflect an initial lateralization period which is not complete until much later in the development of the child. In this initial period in lateralization, the immature cerebrum remains flexible enough to allow for transfer of functions in the event of trauma or destruction of certain areas. What is being seen in early asymmetries is a prepotentcy for complete lateralization for speech functions. Evidence to support this explanation could be gleaned from findings that significant ear asymmetries at early ages seem somewhat dependent on the type, amount, and rate of stimuli utilized as tasks in dichotic listening experiments with children. In adults, however, significant ear asymmetry is almost universally found, regardless of the stimuli used. Evidence of speech lateralization at early ages does not necessarily conflict with clinical evidence on recovery of speech function after lateralization has taken place. The clinical evidence simply tells us that this early speech lateralization is not irrevocably fixated in one hemisphere and that it can never be subserved by the other.

An additional finding concerned the relationship between Sex and ear asymmetry. No significant between Sex effects or interactions involving Sex were found in the regression analysis, implying that males and females performed essentially the same in the present study. This finding is very similar to the Bakker et al. (1973) study in which Sex was not a significant variable and was found to account for 0.7% of the total variance. This also supports the earlier work of Kimura (1963), and Knox and Kimura (1970). It is clear that there is very little difference between males and females in either the age of onset or the development of ear asymmetry.

The present study is unique in attempting to determine whether developmental differences in ear asymmetry exist between races. For this purpose the performance of white children and black children at each age were compared, while attempting to hold social class constant. Therefore, only subjects who were determined to be in the low socioeconomic class were utilized in attempting this differentiation. It was hoped that by this stratification both racial groups would have had a somewhat comparable socioeconomic developmental environment. There can certainly be questions raised as to whether a valid comparison can be made between the environment of blacks and whites, even within general social class boundaries. This is recognized and for the purposes of this study every effort was made to control for these differences whenever possible. For instance, all the low class children attended the same school and thus, because busing was minimal, lived in the same general neighborhood. Despite the possible cultural differences, it was found that there were no significant between Race main effects or interaction effects. These results should lend clarification to those found by Geffner and Hochberg (1971). It was impossible to conclude whether the differences they found were truly social class differences or racial ones because of the predominance of whites in their middle class and of blacks in their low class. The present results suggest that there are no racial differences between black and white children in the development of ear asymmetry.

It was hypothesized that differences in social class might be associated with differential development of the ear asymmetry. A significant ear asymmetry was, in fact, found at all ages in both social classes. This generally is in agreement with Geffner and Hochberg (1971) in that significant social class differences were found. However, it stands in contrast to their study in which they found that the age of onset for their low socio-economic group was seven years of age. In the present study, the five year olds of both classes had a significant ear asymmetry. This is similar to the findings of Knox and Kimura (1970), who utilized children of a low socio-economic background and found a significant asymmetry in their five year old children.

It can be seen from Figure 2 that the total right ear score for the middle class S's has seemed to reach an asymptote by nine years of age. The right ear scores of the low class S's, on the other hand, continue to increase systematically until age eleven years. At this point the right ear scores for the low class are approaching the right ear scores for the middle class. It might be suspected that at this point the low class scores would also begin to level off, a maximum asymmetry having been reached.

These data could be explained by hypothesizing a lag effect in the development of the right ear scores of the low class S's. This would be similar to the explanation proposed by Geffner and Hochberg (1971). If the right ear scores for the five, seven and nine year old middle class S's are compared to the right ear scores of the seven, nine and eleven year old low class S's (Figure 3) it can be seen that the scores are approximately equal. This reveals about a two year lag in the attainment of total right ear recall between social classes, which by age eleven is much smaller, though still significantly different. One can only speculate as to the cause for these social class discrepancies. It might be that there are actual physiological differences between children of varying social classes as suggested by Bloom (1964). These physiological differences may be also found in the developing brain. Diamond et al. (1972), and Rosenzweig and Bennett (1969) have shown that differential environments do have significant effects on brain development in animals. Kagan (1970) has shown that there are differences in the verbal stimulation that children of low class and middle class receive, with the middle class children receiving much more direct verbal stimulation from their parents than their low class counterparts. It may well be that environmental stimulation has a great deal to do with the development of brain function and that children of the lower classes are not exposed to the same quantity and/or quality of stimulation as middle class children. Further work in this area is definitely warranted before many of these questions can be answered.

The present study has attempted to answer several questions which have important bearing on the study of the ear asymmetry phenomenon. It was found that males and females do not develop differently in this regard. It was also found, at least for children from low socioeconomic backgrounds, that blacks and whites perform equally well on a dichotic listening task. There was however evidence for a significant Social Class differences in the development of the ear asymmetry. This difference, however, seems to be one of degree rather than kind. Both the middle and low class S's showed a definite right ear superiority at all ages, but the middle class S's exhibited a significantly greater magnitude of right ear superiority than the low class subjects. The precise age at which the ear asymmetry has its initial onset has still not been determined. It seems clear, however, that the onset is at an earlier age than was originally thought. A strong asymmetry was seen at the youngest age level in the present study, five years. As to the development of this asymmetry over age, it was shown to remain highly significant through the oldest age level studied, eleven years. There is a trend for the asymmetry to increase as a function of increasing age but this did not reach statistical significance. The present findings, in summary, strongly highlight the role of maturational and socio-cultural variables in the development of the ear asymmetry.

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BIOGRAPHICAL SKETCH

Thomas Dennis Borowy was born November 21, 1946 in Baltimore, Maryland. The initial twelve years of his education were in private, parochial schools and were completed with his graduation from Mount Saint Joseph High School in 1964. He enrolled in Towson State College where he completed his B.S. degree, majoring in psychology, in 1968. In the fall of that year he enrolled in the graduate school of Towson State College in the School Psychology Program as well as being employed by the Psychological Services Division of Baltimore City Public Schools. He received his M.A. degree in 1970. He enrolled in the graduate school of the University of Florida in 1970 and received a M.S. in clinical psychology in 1971. Having completed formal studies in 1972 he initiated his clinical internship at the University of Florida in the fall of that year.

He has been the recipient of a graduate assistantship at Towson State College, a University of Florida Graduate School Fellowship, and United States Public Health Service Fellowships. He is a member of Phi Kappa Phi.

In November of 1969 he married the former Patricia Cox.

APPENDIX

MEANS OF TOTAL SCORES ON THE DICHOTIC LISTENING TASK

AGE	SEX	CLASS	RACE	LEFT EAR MEAN	RIGHT EAR MEAN
5	Male	Middle	White	29.6	47.2
7	Male	Middle	White	35.2	50.8
9	Male	Middle	White	51.8	61.0
11	Male	Middle	White	49.6	58.4
5	Female	Middle	White	33.0	42.0
7	Female	Middle	White	46.4	48.2
9	Female	Middle	White	50.4	55.4
11	Female	Middle	White	46.4	57.0
5	Male	Low	White	37.6	38.4
7	Male	Low	White	40.8	40.4
9	Male	Low	White	38.4	46.8
11	Male	Low	White	49.0	49.0
5	Female	Low	White	40.8	40.4
7	Female	Low	White	43.2	49.4
9	Female	Low	White	53.8	59.2
11	Female	Low	White	40.2	60.0

MEANS OF TOTAL SCORES ON THE DICHOTIC LISTENING TASK (Continued)

AGE	SEX	CLASS	RACE	LEFT EAR MEAN	RIGHT EAR MEAN
5	Male	Low	Black	36.4	40.8
7	Male	Low	Black	38.2	45.0
9	Male	Low	Black	39.4	49.0
11	Male	Low	Black	51.8	56.0
5	Female	Low	Black	32.6	36.6
7	Female	Low	Black	37.6	40.2
9	Female	Low	Black	39.8	49.2
11	Female	Low	Black	44.4	58.0

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Paul Satz

Paul Satz, Chairman
Professor of Clinical Psychology

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Hugh Davis

Hugh Davis, Co-Chairman
Professor of Clinical Psychology

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Vernon Van de Riet

Vernon Van de Riet
Associate Professor of Clinical
Psychology

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Audrey S Schumacher

Audrey Schumacher
Professor of Psychology

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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This dissertation was submitted to the Department of [illegible] Psychology in the College of Arts and Sciences and to the Graduate Council, and was accepted as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

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